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Late Pleistocene Faunal Extinctions in Southern Patagonia

Abstract. *Major environmental changes recorded in pollen records from various sites in southern Patagonia and Tierra del Fuego are also reflected in pollen and cuticle data from dung of the late Pleistocene groundsloth. The most prominent change was the large-scale reduction of steppe environment about 10,000 years ago, which coincides with the latest dates for extinctions of many large grazers such as the giant groundsloth. Stress on food resources for all the large grazers may well have hastened their extinction. Hunting pressure by paleoindians may have been the final blow.*

Darwin's (*1*) gloomy description of the environment and aboriginal life-style in the southernmost part of South America provided a background for the much publicized find in 1895 of the nearly complete skin of a giant groundsloth (*Mylodon*) in a cave near the Ultima Esperanza inlet in southern Chile (*2, 3*). Because of its fresh appearance and presumed butcher marks, researchers assumed that the animal might still roam and be hunted by the Indians in some remote areas (*2*), and a British newspaper mounted an expedition to attempt to capture the animal (*4*). Since the discovery of the original Mylodon Cave, which yielded groundsloth skin, bones, and dung, many more such sites have been found in southern Patagonia (Fig. 1). Remains of other extinct taxa, such as native horse *(Onohippidium)*, fox *(Dusicyon)*, and extinct guanaco *(Lama gracilis)*, were discovered as well as remains of extant fauna such as the modern guanaco *(Lama guanicoe)*, tuco-tuco *(Ctenomys)*, and various birds.

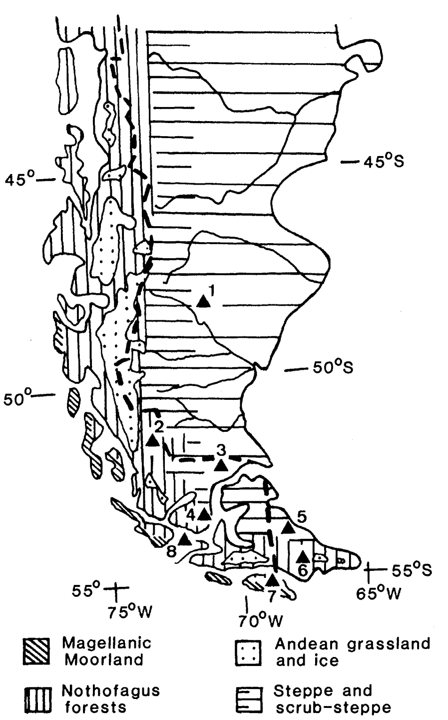

Fig. 1. Map of southernmost South America (Chile and Argentina) showing major vegetation types and site localities mentioned in text: 1, Los Toldos; 2, Mylodon Cave; 3, Fells Cave and Palli Aike shelter; 4, Puerto Hambre; 5, La Mision; 6, Lago Yehuin; 7, Isla Navarino; and 8, Isla Clarence.

Most extinct fauna were found at archeological excavations that were undertaken to determine the antiquity of man in South America. Data on cultural remains from cave and shelter sites, especially the meticulous excavation of Fells Cave (*5, 6*), proved the contemporaneity of early man and the extinct fauna. Radiocarbon dates on material associated with the oldest phase of human occupation in southern Patagonia are 12,600 ± 600 years before present (B.P.) in Los Toldos (*7*); 11,000 ± 170 and 10,720 ± 300 B.P. for Palli Aike and Fells Cave, respectively (*6, 8, 9*). Radiocarbon dates on the skin and dung of groundsloth range from 13,470 ± 180 to 10,575 ± 440 B.P. (Table 1), with most falling around 12,000 B.P.

Contemporaneity of extinct fauna and artifacts alone is insufficient to prove predation on extinct fauna (*10, 11*) or domestication by paleoindians (*12*). Furthermore, available data suggest that Patagonian paleoindians did not specialize in hunting the now extinct fauna (*13*), but primarily killed now extant taxa, preferentially guanaco, small mammals, and birds (*5, 8*). This implicates factors other than just predation pressure (or human overkill) (*14*) in the late Pleistocene faunal extinctions in southern Patagonia.

The foremost alternative proposal to human overkill is paleoenvironmental change. Past changes in vegetation in southern Patagonia and Tierra del Fuego, interpreted from dated pollen and plant macrofossils contained in sediment sections from lake, bog, and cave sites (*15–19*), strongly suggest a climatic cause of faunal extinction. Analysis of cuticle material and pollen in groundsloth dung reveal shifts in the animals' dietary habits that are similar to the vegetational changes.

Pollen and plant macrofossil records that reflect changes in vegetation and climate (Table 2) are known from (i) the steppe and desert-scrub environment of eastern Patagonia (Fells Cave), (ii) the mesic steppe environment in eastern Tierra del Fuego (La Mision) (*17, 18*), (iii) the steppe–*Nothofagus* forest transition in Patagonia (Mylodon Cave) (*20*) and Tierra del Fuego (Lago Yehuin) (*18*), and (iv) the *Nothofagus* rainforest environment in the western Magellan Strait and the Beagle Channel [Isla Clarence (*16, 18*) and Isla Navarino, Puerto Hambre (*19*)].

The steppe and desert-scrub record from Fells Cave (Table 2) shows only one environmental change during the last 11,000 years. This is a shift from mesic

Table 1. Radiocarbon dates on groundsloth dung from Mylodon Cave.

Sample	Date (B.P.)
GX-6248	10,575 ± 400
C-484*	10,832 ± 400 (*25*)
GX-6243*	10,880 ± 300
GX-6246*	11,775 ± 480
BM-1210	11,810 ± 299 (*8*)
GX-6247*	11,905 ± 335
GX-6244*	12,020 ± 460
A-2445	12,270 ± 350
BM-1210B	12,308 ± 288 (*8*)
A-2447*	12,240 ± 150
GX-6245*	12,285 ± 480
BM-1209	12,496 ± 148 (*8*)
BM-1375	12,552 ± 128 (*8*)
A-2448*	12,870 ± 100
A-2446*	13,470 ± 180

*Analyzed for cuticle and pollen.

grassland to the modern desert-scrub between 11,000 and 10,000 B.P. Modern vegetation-climate analogs indicate that this shift represents a decrease in annual precipitation from about 400 to about 250 mm or an increase in temperature that lowered the effective moisture by that amount.

In sites further south and west, where precipitation increases across the Andes from the modern steppe to *Nothofagus* woodland and *Nothofagus* rainforest environments, a greater diversity of paleoenvironmental changes occurred. Before 8500 B.P. there were shifts only in treeless vegetation, suggesting that temperature and precipitation remained below the modern threshold for *Nothofagus* tree growth.

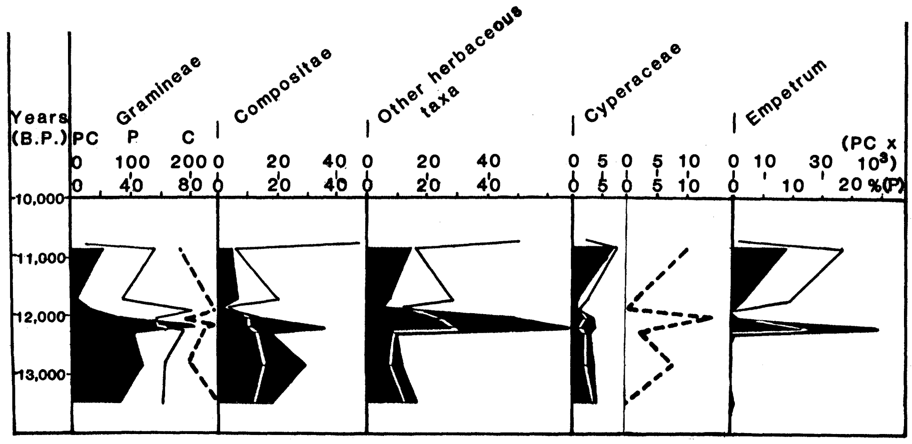

Fig. 2. Pollen data in concentration per gram (PC) and percentages (P) and plant cuticle data in percentages (C) on *Mylodon* (groundsloth) dung from Mylodon Cave in southern Patagonia.

The oldest change recorded was that of a species-poor grassland into a species-rich herbaceous and shrubby grassland at La Mision shortly before 10,000 B.P. (Table 2). The apparent increase in diversity suggests an increase in temperature not precipitation, since increasing precipitation should have favored expansion of *Nothofagus*. This condition lasted until shortly before 9000 B.P., when a moorland vegetation replaced the species-rich grassland, a shift probably reflecting lower temperatures such as those of the Magellanic Moorland on the west coast of Tierra del Fuego today. At 8500 B.P. *Nothofagus* expanded at once across the high southern latitudes, implying an increase in precipitation and temperature to modern levels.

Precipitation varies today according to the location of a site along the trans-Andean precipitation gradient, and it showed equal variation in the past. Thus, *Nothofagus* woodland became established in eastern Tierra del Fuego under about 400 mm mean annual precipitation (La Mision and Lago Yehuin), mixed deciduous–evergreen *Nothofagus* forest further west toward the Andes under about 1000 mm (Mylodon Cave), and rainforest west of the Andes with over 1000 mm (Isla Clarence).

Thus, several large vegetational changes that occurred throughout the high southern latitudes between 11,000 and 8500 B.P. represent repeated incidences of environmental instability during the period of faunal extinction. The modern desert-scrub grassland, which today covers most of Patagonia, was the most strongly affected region; before 11,000 B.P. mesic grassland expanded throughout.

How and to what extent these vegetational changes influenced faunal extinc-

Table 2. Paleoenvironmental history (*18*) and human occupation (*5*) in southern Patagonia and Tierra del Fuego.

Year (B.P.)	Fells Cave	Mylodon Cave (*20*)	La Mision (*18*)	Navarino (*19*)
2500	Fell V	Deciduous forest *Nothofagus pumilio*/ *N. antarctica*	Steppe expansion	
4000	Fell IV Compositae-herbaceous taxa; Gramineae	Mixed evergreen/deciduous forest *Nothofagus betuloides*/ *N. pumilio*/ *N. antarctica*	*Nothofagus antarctica*-woodland w. *N. pumilio*	Heath expansion: *Empetrum*
6000	Fell III Compositae-herbaceous taxa; Gramineae; low pollen concentration	Deciduous *Nothofagus* forest *N. pumilio*/*N. antarctica*	Gramineae increase, more open *Nothofagus* woodland	Densest *Nothofagus* forest
8500	Fell II Compositae-herbaceous taxa; Gramineae; Compositae pollen concentration high; *Perezia*; arid steppe-desert scrub	*Nothofagus betuloides* rainforest expansion *Samolus, Maytenus, Empetrum, Marsippospermum*	*Nothofagus antarctica* woodland expansion	*Nothofagus* expansion
9000		Gramineae, *Perezia, Berberis*; steppe with arid taxa	Cyperaceae, *Empetrum* increase; boggy species-poor steppe	
10,000	Fell I *Ephedra* increase; Gramineae decrease		Gramineae, *Acaena, Berberis* Compositae, increase; rich shrub-steppe	Tundra
11,000	Gramineae, herbaceous taxa, codominant, Compositae low, cold steppe	Gramineae, Cyperaceae, Compositae, *Oreobolus*; steppe with cold taxa	Gramineae, Compositae, Cyperaceae; species-poor steppe	

tions is difficult to assess because preferences of the extinct fauna such as dietary habitats, are not known. Cuticle and pollen analyses of the dung material of the giant groundsloth in southern Patagonia, however, reveal links between vegetational shifts and shifts in dietary habits of the extinct groundsloth (Fig. 2). Studies of the North American groundsloth (*21–24*), on the other hand, indicate that in the American Southwest, *Nothrotheriops shastaense* was a browser on xerophytic plants that were available before and after its disappearance, indicating that food resource problems did not cause extinction.

Fifteen samples of dung of the Patagonian groundsloth have been dated from Mylodon Cave (Table 1). To investigate dietary habits and general environmental conditions at the time that *Mylodon* lived in southern Patagonia, cuticle remains and pollen in nine of the samples were analyzed. The data from cuticles (Fig. 2) indicate that these animals were grazers, not browsers, in contrast to their North American counterpart. Their diet consisted of 80 to 95 percent grasses, 5 to 20 percent sedges, and only traces of herbaceous taxa. The pollen data revealed a much greater plant diversity than the cuticle data, reflecting the general environment as well as the diet (*24*). Even though there is considerable variability between the samples (percentage of pollen, pollen concentration, and number of taxa), the major pollen types indicate several paleoenvironmental trends through time. Samples with dates prior to 12,000 B.P. show higher percentages and concentrations of Gramineae and Compositae than the younger samples, which show more *Empetrum*. The youngest sample dated (10,832 ± 400 B.P.) and analyzed for pollen by Salmi (*25*) shows pollen proportions that are quite different from all the other samples, with Compositae and herbaceous taxa dominating and Gramineae low.

This sequence of changes in pollen is similar to the vegetational changes discussed above (Table 2). In all records there is an evident shift between 11,000 and 10,000 B.P. from a cold, mesic environment to a more arid and warmer environment. This change is expressed as a shift from a species-poor grassland to a species-rich shrubby grassland with taxa characteristic for increased aridity. These specific taxa are different at different sites and include *Acaena* and *Berberis* (La Mision), *Empetrum*, *Berberis*, and *Perezia* (Mylodon Cave), and *Ephedra* and Compositae (Fells Cave). The environmental characteristics and contemporaneity of this shift in all records, including the dung material of the extinct fauna, suggests a direct link between vegetation change and dietary response of the fauna.

In conclusion, I propose that the series of paleoenvironmental changes in southern Patagonia and Tierra del Fuego during the time of faunal extinction directly affected the food resources, both in area and in character, and created a stress for the animals that cannot be discounted in extinctions. The additional stress of paleoindian hunters might have been the final blow that led to the extinction of some of the already more decimated beasts, while others such as the guanaco, less specialized in its diet, returned eventually to roam the Patagonian lands again.

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A Sexually Dimorphic Nucleus in the Human Brain

Abstract. *A sexually dimorphic cell group is described in the preoptic area of the human hypothalamus. Morphometric analysis revealed that the volume of this nucleus is 2.5 ± 0.6 times (mean ± standard error of the mean) as large in men as in women, and contains 2.2 ± 0.5 times as many cells. Between the ages of 10 and 93 years, the nucleus decreases greatly in volume and in cell number. Although no function has yet been established for this nucleus, it is located within an area that is essential for gonadotropin release and sexual behavior in other mammals.*

The literature of the past century on the possibility of morphological sex differences in the human brain is a mixture of scientific observations and cultural bias, in which male and female "superiority" were alternately contended (*1, 2*). Until recently, however, Mall's conclusion that "each claim for specific [sex] differences fails when carefully tested" (*3*, p. 27) held true with respect to the human brain, apart from the sex difference in overall size of the brain (*1*). A few years ago a sex difference in the shape of the corpus callosum was described (*4*), and recently the shape of the suprachiasmatic nucleus (SCN) was found to be sexually dimorphic (*1*). Yet, to our knowledge, no sex difference in cell number has been reported for any human brain area. On the other hand, since Raisman and Field (*5*) reported sex differences in the synaptic organization of the preoptic area in the rat, reports pertaining to gender-linked differences in many brain components throughout the animal kingdom have increased (*1*). The most conspicuous of these sex differences was described by Gorski *et al.* within the rat brain (*6*), in the preoptic area (POA). A cell group within this area revealed such a clear cytoarchitectonic sex difference that it could even be seen with the naked eye in Nissl-stained sections. We have studied an analog of this sexually dimorphic nucleus (SDN) of the POA in the human brain. Morphometric analysis demonstrates that the SDN-POA is 2.5 ± 0.6 times [mean ± standard error of the mean (S.E.M.)] as large in men as in women and contains 2.2 ± 0.5 times as many cells.

Brains of 13 men and 18 women between 10 and 93 years of age were fixed, generally for 1 month, in Formalin. Serial coronal sections (6 μm) were taken from the hypothalamus and stained with thionin (*7*).

As has been reported for the rat (*6*),